Abstract

This thesis addresses the problems of collision avoidance and coalition formation of multiple UAVs in high density traffic environments, proposes simple and efficient algorithms as solutions, and discusses their applications in multiple UAV missions.

First, the problem of collision avoidance among UAVs is considered and deconfliction algorithms are proposed. The efficacy of the proposed algorithms is tested using simulations involving random flights in high density traffic. Further, the proposed collision avoidance algorithms are implemented using realistic six degree of freedom UAV models. The studies in this thesis show that implementation of the proposed collision avoidance algorithms leads to a safer and efficient operational airspace occupied by multiple UAVs.

Next, coalition formation in a search and prosecute mission involving a large number of UAVs and targets is considered. This problem is shown to be NP-hard and a sub-optimal but polynomial time coalition formation strategy is proposed. Simulations are carried out to show that this coalition formation algorithm works well. The coalition formation algorithm is then extended to handle situations where the UAVs have limited communication ranges.

Finally, this thesis considers some multiple UAV missions that require the application of collision avoidance and coalition formation techniques. The problem of multiple UAV rendezvous is tackled by using (i) a consensus among the UAVs to attain rendezvous and (ii) the collision avoidance algorithm previously developed for safety. The thesis also considers a search and prosecute mission where the UAVs also have to avoid collisions among one another.

In summary, the main contributions of this thesis include (a) novel collision avoidance algorithms, which are conceptually simple and easy to implement, for resolving path conflicts – both planar and three dimensional – in a high density traffic airspace with UAVs in free flight and (b) efficient coalition formation algorithms for search and prosecute task with large number of UAVs and targets where UAVs have limited communication ranges and targets are maneuvering. Simulations to evaluate the

performance of algorithms based on these concepts to carry out realistic tasks by UAV swarms are also given.